HEAT

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PREFACE

This pamphlet is offered to physicists for what it is worth and is an attempt to put the subject of thermodynamics on an understandable basis. The salient features dealt with are these:

Heat is a diamagnetic or negative force acting in opposition to the positive force of atomic attraction.

Temperature is the negative atomic stress produced between the atoms.

The work value of the unit of heat is not 778 foot pounds, but is proportionate to the temperature.

The unit of energy 778 foot pounds may apply anywhere on the scale of temperature without reference to the unit of heat.

There is no such thing as latent heat. There is only developed and undeveloped energy.

The properties of different forms of matter cannot be compared by quantities of

equal weight. The specific heat of different materials should be dealt with by equal volumes.

Gases do not expand proportionate to their pressure per square inch, but expanded adiabatically the pressure varies inversely as the square of the distance between the atoms.

A gas and a vapor differ only in the intensity of the force of attraction between the atoms.

The specific heat of matter has no apparent relation to the atomic weights.

The unit of energy 778 foot pounds has no sufficient basis for its adoption.

To prove this may seem like a large undertaking, but the writer feels satisfied that if the pamphlet is carefully perused it will be found that these points have been fully established. It is not given as a full dissertation on the subject, but is presented in the hope that it will make one step forward in developing the latent meaning in our present day thermodynamics.

HEAT

Heat—Diamagnetic Force:

While we do not know what heat actually is, we can best study it as having quantity and conditions in the same way as we deal with electricity by amperes and volts.

Heat, as distinguished from temperature, may be said to be that which produces a negative, repulsive or diamagnetic force between the atoms tending to produce expansion or tending to overcome or reduce the positive force of attraction and cohesion. Temperature indicates the condition or intensity of the negative stress between the atoms and indicates the condition under which heat will pass from one body to another, but does not indicate the number of units of diamagnetic energy present. Temperature indicates the frequency of the vibration induced by the transfer of diamagnetic force from one body to another. No

two forms of matter have the same specific heat, because no two forms of matter have a force of atomic attraction of the same intensity.

Unit of Heat—Unit of Energy:

The heat unit as now defined, viz.:—"The amount of heat necessary to raise one pound of water from 499° F. to 500° F. and having a work value equivalent of 774 ft. lbs." —though definite in itself, does not seem to be clearly understood in some respects. The definition states quantity and condition without differentiating between them. "One unit of heat" defines a definite quantity which has no work value whatever as no condition is stated, and may be characterized as the diamagnetic force produced in one unit of matter, but "One unit of heat" developed at the heat density or diamagnetic stress equivalent to 500° F. temperature in water, has a work equivalent of about 774 ft. lbs., just as one ampere of current has no work value, but one ampere of current

at 500 volts pressure has an established work value.

The heat unit as defined may be described in two entirely distinct and separate ways, viz.: producing one unit of heat as by friction from zero to 500°, equivalent to about 774 ft. lbs., or as in raising the temperature of 500 units of heat in the one lb. of water 1°, equivalent to about 774 ft. lbs., so that when we raise the temperature of one lb. of water from 499° to 500° we actually increase the temperature of 500 units of heat one degree, increasing the diamagnetic force the equivalent of 774 ft. lbs., and this should be called one unit of diamagnetic energy, not one unit of heat.

The one unit of matter as associated with one unit of heat as defined is, therefore, 1/500 of one lb. of water.

The action may be compared to raising 1.55 lbs. of water from sea-level to a height of 500 feet, equal to 775 ft. lbs., this being similar to increasing the temperature of one unit of matter from zero to 500°, as against

raising 775 lbs. of water one ft. high from 499 ft. to 500 ft. equal to 775 ft. lbs., this being similar to increasing the temperature of 500 units of matter one degree from 499° to 500°.

B. T. U.:

The British Thermal Unit as used in thermo dynamics does not relate to heat and temperatures except in an indirect way. The work equivalent of B. T. U. 778 ft. lbs. is supposed to be the work equivalent of one unit of heat as defined or one unit of heat developed by friction against a temperature of 520° absolute. The work equivalent, therefore, applies only to the temperatures from zero to 520° and it has, in fact, no available work value whatever, as the temperatures involved are all below normal.

The B. T. U. as used is an arbitrary unit energy or work similar to the joule and without any direct reference to heat at specific temperatures, it might just as well have

been made any other number of foot lbs. Seeing the ft. lb. is recognized as the unit there seems to be no reason why the larger units should not have been made 10 ft. lbs., 100 ft. lbs., or 1,000 ft. lbs., instead of the irregular figure which has been adopted.

The expression "one unit of heat" is, therefore, inadequate and is not understandable unless the temperature is stated. The expression is used in thermo-dynamics to denote two things which are entirely different. One unit of heat means all the heat present in one unit of matter, because we are dealing with energy and matter, and if the unit of matter remains constant the energy must vary with the temperature. The one unit of energy does not depend on any specific temperatures, but may be the force acting through any range of temperature which will be equivalent to 774 ft. lbs. of work.

One unit of heat at 500° temperature is equivalent to 774 ft. lbs. of diamagnetic energy, and 500 units of heat at 1° temperature are equivalent to 774 ft. lbs. of energy.

Five hundred units of heat at 500° temperature are equivalent to 387,000 ft. lbs. of energy; 500 units of heat at 1° temperature are equivalent to 774 ft. lbs., or one unit of diamagnetic energy as defined and is similar to 500 joules. One unit of heat at 500° temperature is convertible into two units of heat at 250° temperature without loss of energy. In other words, half the quantity at twice the condition is equal to twice the quantity at half the condition.

One unit of heat is the heat necessary to produce a diamagnetic force in one unit of matter, and its equivalent in energy is proportionate to its temperature when the volume or state of the matter is not changed; the one unit of matter under the definition being 1/500 of one lb. of water.

In no two kinds of matter does the absorption of one unit of diamagnetic energy produce the same rise in temperature because no two kinds of matter have a force of atomic attraction of the same intensity and the specific heat of all forms of matter

changes with the temperature change, so that no kind of matter in the solid or liquid state can be used satisfactorily in defining the one unit of matter in its relation to one unit of heat as determined by temperature. A perfect gas at constant volume would fulfill the requirements best, because such a gas would have no resistance except that due to pressure.

Temperature—Vibro-Frequency:

Temperature is an index of the diamagnetic energy present in a perfect gas only; in matter under other conditions it is no index at all. Temperature is an index of the intensity of the negative stress or repulsion between the atoms in solid matter, but part of the energy added to a solid or liquid acts to decrease the force of attraction and is not indicated by temperature, although the amount of energy absorbed to produce liquification is, in a general way, proportionate to the intensity of the cohesion when the matter is pure. Great variations seem to

occur in all solids, because different proportions of the heat absorbed goes to change the physical characteristics of the material without changing the temperature. The vibro-frequency which is induced by the transfer of heat is determined by the diamagnetic stress or temperature.

When heat is added to a solid under ordinary conditions the action is two-fold. It increases the force of repulsion or temperature and at the same time decreases the force of attraction or cohesion and the extent to which these forces change relatively determines the extent of the temperature change, if any, per unit of diamagnetic energy added. The decrease in the force of attraction which is produced represents internal developed energy and does not affect the temperature.

When heat is added to a body at a uniform temperature each unit of heat so added has the same work equivalent.

To transfer one unit of heat to one lb. of water at 500° we must first build up the

temperature of the heat unit to the required intensity, using energy to do so proportionate to the temperature, just as we must build up the voltage of an electric current to the required intensity before it will pass through a conductor already charged. In each case it is equivalent to building these up from zero to the required intensity when we deal with absolute conditions, as in producing one unit of heat by friction, because we thereby produce a new unit of force with energy proportionate to the temperature and it is equivalent to the force in 1/500 of the water at 500° temperature.

So long as we consider 1 lb. of watery vapor at 30° temperature to be different from 1 lb. of ice at 30° temperature, we must, to be consistent, consider heat and temperature apart.

The thermometer scale is a scale of temperature not of heat. It is a scale of equal degrees or units of diamagnetic energy in a gas as evidenced in expansion, but the work derived from a gas in adiabatic expansion is

derived from the matter under a diamagnetic force of practically constant intensity in the atoms; the unit of heat, therefore, relates to the unit of matter. It is the diamagnetic force produced in one unit of matter and its equivalent in energy is proportionate to the temperature in a gas when the volume is not changed. We cannot have work in foot pounds except through the agency of ponderable matter.

The temperature of a body may be reduced in two ways. By decreasing the diamagnetic stress, by the radiation of heat, and by decreasing the diamagnetic stress by moving the atoms apart as in gaseous expansion, increasing the distance through which the force acts, thereby in both cases decreasing the frequency of the vibration by decreasing the stress. In the first case the diamagnetic force is transmitted to some other body. In the second case the diamagnetic force remains the same, but the stress is reduced by increasing the distance between the repelling atoms.

Latent Heat—Developed Energy:

There is no such thing as latent heat. When we add one unit of heat to any substance a definite physical change is produced. This may be accompanied by rise in temperature or it may not, depending upon whether the negative stress between the atoms is increased or not, thus if the atoms are free to move apart relieving the stress as in expanding gases, the temperature will immediately drop proportionately as the stress is reduced, but the repulsive force of the atoms will not be materially changed, only the distance through which the force acts has been increased.

When we add heat under temperature to a body we impart energy to the body as diamagnetic force, and in dealing with gases the changes which take place in adiabatic expansion may be defined as developed and undeveloped energy. The developed energy is represented by the volume and the undeveloped energy is indicated by the temperature or stress; thus when we add one unit of

energy to a gas at constant volume, we add to it one unit of undeveloped energy as indicated by the increase in temperature, and the unit of energy is re-convertible into work by expanding the gas to complete relaxation when it becomes entirely developed energy. Diamagnetic force acting without resistance produces no temperature and represents no energy.

When the temperature of a solid, liquid, or vapor is increased, part of the energy goes to decrease the force of attraction, and this energy is internally developed energy in that it does not increase the temperature. When the temperature of the material is reduced by the radiation of heat, the developed energy comes back as undeveloped energy as the force of attraction reasserts itself, as the internal atomic stress of the matter is reduced.

Specific Heat—Diamagnetic Resistance:

The way in which the specific heats of the various materials are now given and com-

pared is not only misleading, but is unscientific. We do not in fact deal with units of heat but with units of energy and the relation may be characterized as diamagnetic resistance.

To take the specific heat of the various materials by units of equal weight, means comparing the properties of altogether unequal quantities of matter, because weight is not a property of the body we weigh, but is purely a conditional relationship between the body we weigh and the attracting mass, —the earth. If we could change the earth's mass, we would thereby change the weight of the object if weighed on a spring balance and there does not seem to be much reason to doubt that if the earth's composition and state were changed it would entirely change the relationship of the specific gravities— in short, a planet might exist on which aluminum would be the heaviest metal and platinum the lightest. No two planets are accredited with the same density. There is no reason to believe that there is not just as

much matter in one cubic foot of iron as there is in one cubic foot of lead, although the specific gravities are different.

Cohesion is a property of the object we deal with, and strength of material is a volumetric quality. The action of heat by units of energy on matter also gives a volumetric result; so in dealing with specific heats for comparison, we should deal with equal volumes of matter not with equal weights.

The following table gives diamagnetic resistance per cubic foot at about 40° F. and speaks for itself:

TABLE

Metal	Specific Heat	Weight C. F.	Diamagnetic Resistance C. F.	Tensile Strength per sq. in. lbs.	Melting Temperature
Nickel	.109	548	59.97	80,000	3560°
Iron	.1138	480	55.58	60,000	3260°
Copper	.095	552	52.44	34,000	2390°
Platinum	.032	1347	43.10	50,000	3660°
Silver	.057	655	37.33	36,000	2210°
Gold	.032	1200	38.40	20,000	2432°
Aluminum	.214	167	35.1	20,000	1675°
Zinc	.095	436	41.42	6,000	1240°
Tin	.056	458	25.64	5,000	902°
Lead	.031	709	21.97	3,000	1085°
Antimony	.051	421	21.42	1,000	1270°

The figures are irregular, but we do not know the exact quantities in any one case and the diamagnetic resistance changes with change of temperature, also energy is absorbed without change of temperature while fusion takes place. The strength should be taken per cubic or spherical inch to show the full strength of the material to resist disgregation. Even with the limited knowledge available the way in which the diamagnetic resistance, cohesion and melting temperatures follow each other would seem to show clearly that we cannot compare the properties of different forms of matter by quantities of equal weight.

The strength of a material, from the standpoint of overcoming the cohesive force by heat, is not the strength of the material to resist tensile strains in a solid bar, although this in pure metals indicates to a certain degree the intensity of the cohesive force, but it is the resisting force of the atoms to prevent disassociation. In other words, the attractive force of the atoms in

adhering to each other. So the true strength of the cohesive force is indicated by the amount of energy absorbed to produce the temperature of vaporization. When we deal with metals by tensile strength only, the physical conditions of the material as to structure may modify the strength greatly, but this does not change the temperature at which fusion will take place. A metal may increase in tensile strength when the temperature is increased, due to structural changes, but the ultimate cohesion of the atoms, or temperature of vaporization, would remain the same.

Not only is the custom of comparing specific heats in quantities of equal weight misleading, but the custom of reckoning specific heats by temperature is also misleading. Heat added to a body does not always produce rise in temperature and great change in the temperature may occur without withdrawing or adding any heat. Temperature alone is, therefore, not a sufficient basis to go by.

The action of diamagnetic energy on matter, as indicated by temperature, is dependent on the relationship of the atomic forces.

In dealing with solids, the extent to which the force of attraction is modified determines the rise in temperature due to the absorption of one unit of energy. In a general way the diamagnetic resistance as determined by temperature is proportionate to the intensity of the cohesive force. Metals with great strength have a higher resistance than those the cohesion of which is low, and so we find in pure metals the energy absorbed to produce fusion and tensile strength conform in a general way.

In a liquid the temperature change is dependent on the external pressure and internal stress, and the decrease in the force of attraction which occurs as heat is added to the liquid. The lowering of the force of attraction produces an increase in the pressure relative to the temperature.

In a vapor the relations are similar to those of the liquid, except that there is introduced

the element of distance between the atoms in addition to the varying relationship between the forces. In other words, a vapor is a liquid atomized and expanded with a high attractive force, supplemented by external pressure, these being balanced by the force of repulsion.

A perfect gas would be a completely atomized material with the force of attraction practically eliminated, so that the relational change would be dependent on the intensity of the force of repulsion and the distance between the atoms, that is the spherical gaseous pressure would change inversely as the square of the distance between the atoms in expansion if the gas was perfect.

The diamagnetic resistance of any material, which is most nearly correct as indicated by temperature, is the resistance of its gas at constant volume, and when comparisons are made between different gases they should be made not by equal weights of gas, but by equal liquid volumes gasified.

Gases at the same temperature and pres-

sure are said to have the same number of atoms per cubic foot. Gases at the same temperature and pressure have practically the same diamagnetic resistance per cubic foot; therefore, the atoms have the same resistance after the force of attraction has been eliminated, and the action seems to be in no way dependent on the atomic weights.

The outward pressure developed by the atoms in a gas through the addition of heat is dependent on the distance between the atoms and the increase is constant per unit of energy added when the distance is not changed. With vapors the pressure increases much more rapidly than does the temperature, because as the energy is added the force of attraction is decreased, and so the work done by a vapor in expansion is not proportionate to its temperature change.

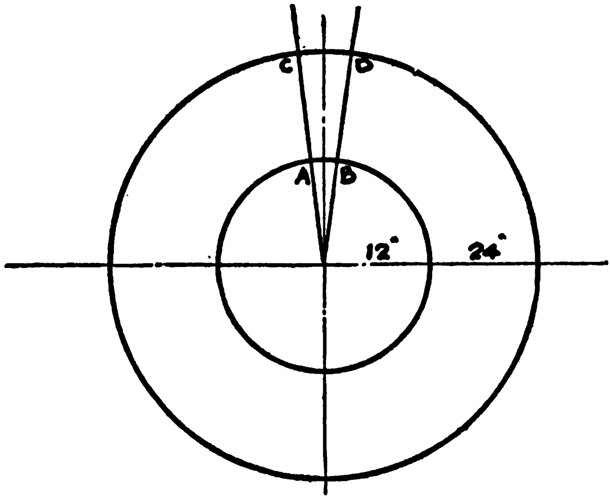
Pressure per Square Inch:

Gases do not expand proportionate to their pressure per square inch. The pressure on one square inch is due to the number

of atoms pressing on that surface acting through the negative potential, or the force of repulsion between the atoms, and to get the relationship in expansion, we must take the force exerted by the same number of atoms in each case. As the gas expands the atoms move apart and so cover a larger surface.

We can most simply get a proper relationship by taking spherical pressures, thus: if a 12-inch sphere contains a given volume of gas, exerting a pressure of 16,000 lbs. on the total internal surface, and we then expand the gas adiabatically to fill a 24-inch sphere, the total internal pressure on the 24-inch sphere will be about 4,000 lbs., and this is very nearly the true pressure change. The atoms have doubled their distance apart in the expansion and the force decreases inversely as the square of their distance apart, modified, however, by a certain expenditure of work necessary to overcome the attraction of the atoms for each other. If the pressure on one square inch, as at A, B, on the 12-

inch sphere is 36 lbs., then the pressure on four square inches, as at C, D, on the 24-inch sphere, would be about 9 lbs., and the pressure per square inch at C, D, about 2.25 lbs., if the gas was perfect.



Isothermal expansion is not the expansion of a fixed quantity of gas, but of a quantity of gas continually augmented by additional heat, increasing the force of repulsion and maintaining the stress between the atoms

constant relative to their distance apart, hence the volumetric displacement work of a given weight of gas at the same temperature is the same whatever the volume. Adiabatic expansion is the only true expansion of a gas by which to determine its expansive energy.

That the atomic force producing the gaseous volume is purely a repulsive force can be clearly shown in various ways.

It is inconceivable that sound would be freely transmitted through a gas with the atoms in a state of violent turmoil and confusion which would necessarily result if the pressure was due to the velocity and impact of the atoms; but if we consider that each atom is repelling its neighbor and is tensely held in place at its proper spacing, due to the repulsive force, then we have a medium which would be resonant as a violin string.

Watery vapor at 14.7 lbs. pressure will absolutely prevent the vaporization of water at 212° F., because the repulsive force of the molecule of water in the vapor exactly bal-

ances the repulsive force of the molecule in the liquid, preventing it from being driven off. Now if prevention was due to the impact of the vapor molecule, there is no apparent reason why the impact of the oxygen and nitrogen atoms in air at 14.7 lbs. pressure would not have a similar effect, but it is known that no ordinary pressure of dry air applied to the surface of the water will prevent the water from vaporizing and forming very nearly its normal vapor pressure proportionate to the temperature.

It does not seem possible that the atoms in a gas could vibrate through a space 2,000 times their own volume and maintain a pressure of 14 lbs. per square inch, or in fact that vibration, however intense, would produce any considerable increase in volume at all. Diamagnetic force offers the only logical explanation of the phenomenon.

That vibration does occur is evident, but only when the temperature or stress of adjoining bodies or atoms is different, and the vibration is in fact the mode of transmission

of the diamagnetic force from one atom to another, by the vibration in the atoms of a field of force of varying intensity, the frequency of the vibration being determined by the intensity of the diamagnetic stress. When the stress becomes uniform the effective vibration would probably cease as the impelling force has gone. The vibration could only occur in a gas under a tense condition of the atoms, such as would be produced by a repulsive force. These vibrations in a solid are not necessarily movements of the atoms, but rather vibrations or rapidly varying intensities of the diamagnetic force, for it seems evident that to vibrate the atoms in a field of force, and to vibrate the field of force in the atoms, would produce similar results; so we may say, that while sound is transmitted by the vibration of the atoms, heat, light and electricity are transmitted by the vibration of the force, the frequency of the vibrations in the transmission of heat being determined by the stress or temperature.

While the repulsive force may be due to some form of vibration in the atom, the action, as far as it relates to the atoms relative to each other and as to the development of work by a gas in expansion, the force is purely a repulsive force and is not dependent on the weight of the atoms.

In a gas the atoms may vibrate in synchronism with the vibrating force, but such vibrations probably do not of themselves produce pressure, but rather tend to prevent the transmission of heat.

Broadly speaking, it may be said that any body at a temperature above the surrounding temperature is luminous, that is, it sends out waves of radiance, but only such waves of radiance are visible as have a vibro-frequency within the range of our spectrum. The limitation of the action as perceived by us is, therefore, due to the limited function of our sense of sight.

The reason why the pressure per square inch increases when a gas is compressed isothermally is because a greater number of

atoms press on the square inch of surface as the volume is decreased, while the repelling force between the atoms remain the same. In other words, the same tensity exists at the same temperature, whatever the volume or pressure; hence the same frequency of the vibrations when heat is being transmitted.

It must, therefore, appear that there is no difference in the action when we add heat to a solid and when we add heat to a gas; it simply intensifies the repulsive force of the atoms or its equivalent decreases the force of attraction and the excess of this repulsive force over what is necessary to overcome attraction produces the pressure and available work. The pressure produced by this excess repulsive force decreases inversely as the square of the distance between the atoms in gaseous expansion and the temperature varies with the atomic stress.

The force of repulsion of the atoms of a gas measured at their surface increases proportionately for each unit of energy added, and the pressure on the sides of the vessel

containing a gas increases proportionately for each unit of energy added, so long as the distance between the atoms is not changed; but in expansion without addition of heat, the total pressure on the sides of the containing vessel, if spherical, varies inversely as the square of the distance between the atoms modified slightly by the work necessary to overcome the attraction of the atoms for each other.

From the foregoing it must be evident that there is no such thing as "Latent Heat," as ordinarily defined, each unit of diamagnetic energy added, whether to the solid or the gas, gives a precisely similar result, but its availability for work in expansion is dependent on the relationship of the forces.

The heat which is absorbed in changing ice to water without change of temperature represents developed energy in that it decreases the force of attraction to the point where the two forces exactly balance each other, and at which the atoms become fluid, the temperature of fusion being determined

by the intensity of the force of attraction of the atoms.

The entire action being due both in liquification and combustion, not to any change in the materials but to change in the relationship of the forces.

If we take 73 cubic feet of air at 500° absolute temperature and 14.7 lbs. pressure containing 500 units of energy of expansion, does not $1/500$ of the volume, or .146 cubic feet, contain one unit of energy of expansion? If we add one unit of energy to the 73 cubic feet of air at constant volume, the pressure per square inch will be increased $1/500$ of 14.7 lbs., or .0294 lbs. If we take $1/500$ of 73 cubic feet of air, or .146 cubic feet, and expand it adiabatically to complete relaxation, it will give about 774 ft. lbs. of work, or one unit of diamagnetic energy as defined. The figures are more or less inaccurate, and are given as approximations.

Of course, there may have been more than 500 units of energy needed to produce the 73 cubic feet of air, perhaps several times

that number, but there is only the work equivalent of 500 units of this energy as defined undeveloped by the distance between the atoms, and so we may say 500 units of energy of expansion or undeveloped energy. Temperature in a gas gives no indication whatever of the diamagnetic force of the atoms without taking into account the distance between the atoms, but it does indicate the amount of work which may be derived from the gas in expansion. It indicates the amount of undeveloped energy.

When we expand a gas against resistance it does not thereby lose any heat; what it does lose is temperature. As the spherical pressure in a gas changes inversely as the square of the distance between the atoms in expansion, the repulsive force must remain the same, but acting through an increasing distance the stress and the temperature are reduced; so that a gas may be expanded to complete relaxation and zero without producing condensation. To condense a gas it must first be compressed, increasing the tem-

perature of the contained heat so that it can be transferred. There must be the diamagnetic stress to get the frequency of vibration necessary to transfer the force at the surrounding temperature.

Heat, therefore, is not the equivalent of work, diamagnetic force under no resistance produces no temperature and represents no energy, but heat produces the negative force in the atom, and the temperature is dependent on the proximity of the atoms under the stress, so when a gas is compressed without impact or friction, it does not produce additional heat, but the temperature or atomic stress is increased by pressing the atoms closer together; hence we can heat water by compressing air and transferring the heat with a very small expenditure of work per unit of energy transferred; we simply transfer the energy from one body to another.

When we produce heat by friction, we produce heat which did not before exist under temperature and, therefore, produce it from the zero of temperature.

A gas exists as a gas only because of the heat or diamagnetic force which it contains, and the changes produced by expansion or compression represent modifications of the condition or temperature of the contained heat, and does not add to the number of heat units. If in making the change velocity is imparted to the atoms, as in expansion without resistance, the dynamic action resulting from the atoms in motion may produce additional heat, which would show as increased diamagnetic force and temperature. If, instead, the velocity is imparted to some external object, such as the moving mechanism of an engine, then the force of atomic repulsion will be converted into work. If all the work developed by the expanding gas could be converted into diamagnetic force and retained within the gas developing it, then we may have isothermal expansion, the increase of the repulsive force compensating for the increased distance between the atoms, but no other work would be performed. This may be done by friction converting the ve-

locity of the atoms back into diamagnetic force or heat. Velocity is a force of the atoms relative to the attraction of gravity. Temperature is a force between the atoms relative to each other.

Vaporization:

The following relates to the vaporization of water; other vapors may act in a different way.

The vapor state is an intermediate one between the solid and gaseous. It is an unstable state, being in part dependent for its continuance on external pressure, and as the pressure is changed the vapor is proportionately modified. The change which takes place, which we call change of state, is not necessarily a change in the material as we judge such, but it is a change in the character and intensity of the atomic forces.

The conditions of matter may be described as follows: The solid is matter in which the force of atomic attraction exceeds the force of repulsion. The liquid is that in which the

two forces are equal and balance each other. The vapor exists when the force of repulsion exceeds the force of attraction without superheat, equilibrium being maintained by external pressure. A perfect gas would have no atomic attraction whatever, the only force being that of repulsion, the stress being maintained by external pressure only. Such a gas to us exists only in theory.

Temperature indicates the intensity of the repulsive or diamagnetic stress between atoms. Diamagnetic force acting without resistance produces no temperature, therefore represents no energy, but the resistance may be either that of internal atomic attraction as in a solid or external pressure as in a gas, or a combination of both, as in a vapor, and the intensity of the diamagnetic stress produced is the temperature which is produced, but the outward pressure depends on the relationship of the two forces.

Atomic stress and pressure per square inch should not be confused. Atomic stress is the stress which exists between the individual

atoms as evidenced by temperature, while pressure per square inch is the excess of the repulsive force and is dependent upon the number of atoms acting on the square inch of surface under the excess of the atomic repulsion.

A vapor is, therefore, an atomized material under high internal tension, the force of attraction in the atoms being high. When fusion is produced the attractive force of the atom remains, but it is neutralized by an equal and opposite force.

When ice is reduced to water at 32° F., it assumes the fluid state, the matter being subdivided into innumerable very small bodies which have little or no cohesion among themselves, but are under the stress of the two opposing forces. When heat is added to produce the vapor these small bodies are driven off by the increased repulsive force, and as the negative stress decreases with distance they absorb heat to maintain the isothermal condition. The heat absorbed increases the force of repulsion and compen-

sates for the increased distance through which the force acts. The stress due to the force of attraction of the atoms also decreases with distance, absorbing energy, which decrease serves to maintain the pressure per square inch constant while the temperature remains the same, and it is equivalent to a decrease in the force of attraction.

In expanding water to vapor at constant temperature the developed energy resulting is of two kinds: First, there is the outer work produced by the expansion of the volume against the external pressure; and, second, there is the internal developed energy or work done in expanding the vapor against the internal attraction, or pulling the atoms apart under their high attractive force, and hence the large amount of heat absorbed in maintaining the isothermal condition. This developed energy is what is usually called latent heat of vaporization.

The pressure of the vapor increases as the temperature of the water in contact increases, the water absorbing heat at about

the specific heat of 1.0; a large part of the energy, therefore, goes to decrease the force of attraction in the water, increasing the pressure relative to the temperature.

That this is so is clearly shown thus: The vapor pressure of water at 212° is 14.7 lbs. per square inch. At 213° it is 14.99 lbs., or an increase of .29 lbs. per degree. The pressure of water at 399° is 244.3 lbs., and at 400° is 247.1 lbs. per square inch, or an increase of 2.8 lbs. per degree, or about ten times the increase given at the lower temperature. The pressure has increased much more rapidly than has the temperature, much of the energy having gone to decrease the force of attraction and hence the high specific heat of the water and the steady increase in the specific heat up to about the critical temperature where the force of attraction would be largely eliminated. The atoms in the vapor naturally have the same force of attraction as in the water at the same temperature, which attraction becomes less and less as the temperature rises.

In a gas at constant volume the pressure increases equally for each degree rise in temperature, because the atoms in the gas have very little attraction for each other.

It should be clearly borne in mind that there are in all matter two atomic forces: the force of attraction and the force of repulsion; and when these two forces are equal the material is fluid; with water fluidity occurs at the high temperature of about 496° absolute; hence the force of attraction is intense, and the atoms are in a high state of tension because of the two opposing forces. The existence of the one force implies the existence of the other. The zero of the repulsive force is the zero of temperature of a solid. The zero of the force of attraction exists only in a perfect gas, but in the ordinary gases this force is very low at normal temperature.

When heat is added to a body—in the general concept of the subject—the temperature is increased. This, while in a measure true, is very far from being the whole truth,

and altogether depends on conditions. When the force of attraction in a body is increased the temperature is increased, or the equivalent heat is given off. When the force of attraction in a body is decreased the temperature drops or the equivalent heat is absorbed. The simplest example of this is in the freezing of water and the melting of ice. The change in the force of attraction must take place progressively as the ice melts to bring about the transfer of the heat isothermally.

When oxygen and hydrogen are combined in combustion the temperature is increased and the force of attraction is increased, the fusion temperature rising to 32°. When oxygen and hydrogen are disassociated the temperature is reduced and the force of attraction is decreased, the temperature of fusion going down to below —300°, and the heat given off in the one case is believed to be the same in amount as the heat absorbed in the other. Many instances of similar action can be cited. The change may be marked

by a sudden change in the temperature, or by the absorption or rejection of heat. With some forms of matter this action is entirely reversed, heat being absorbed freely when they combine, lowering the temperature, and the resultant compound may have a melting temperature much below that of the constituent elements, thus showing the positive and negative character of the forces, and also showing the action of heat in lowering the temperature and lowering the force of attraction when a compound is formed. Instances of this occur when ice and salt are mixed and when slags are formed in smelting.

To say that every material atom attracts every other atom is simply not true, and is refuted on every hand. The atomic forces not only change their intensity, but they also change their potential under certain conditions, and atoms of dissimilar kinds may attract, repel or be neutral to each other, depending on the character of the forces. These changes may not affect the gravity or

weight of the atoms, because the weight results from the attraction of the earth for the atoms, and the earth does not change.

It would thus appear that while we generally think of heat as producing increase in temperature, it really does, in some cases, produce the equivalent of a drop in temperature, while in others no change in temperature takes place when heat is added, all the heat going to decrease the force of attraction without change of temperature.

When ice is changed to water at 32°, 144 units of energy are absorbed isothermally per pound of ice melted. As the energy is absorbed the force of attraction is reduced to the point where the two forces neutralize each other, the change affecting one atom at a time, thus keeping the temperature constant. The heat absorbed does not become latent; it lowers the force of attraction, that is, it produces internally developed energy without changing the temperature. Some materials, when they solidify, develop high temperature at once, but with water the en-

ergy is given off isothermally as it changes to the solid state, as the force of attraction reasserts itself.

The nearest approach we can have to the true specific heat of a material, as evidenced by temperature, is, therefore, in the gaseous state under constant volume, and any increase in the specific heat at constant volume over this amount would seem to indicate that part of the energy added to the body goes to decrease the force of attraction. This would apply to solids, liquids, or vapors, and to gases to a slight degree, as no gas we know of is perfect.

When the force of attraction is reduced by the absorption of energy the change may produce an available work equivalent, similar to an increase in the repulsive force or increase in temperature because it decreases the amount of the repulsive force which is neutralized by the force of attraction, hence increasing the pressure relative to the temperature, and it is the difference between the

two forces which determines the outward pressure producing work in expansion.

When a liquid is formed and the force of cohesion of the mass is neutralized, pressure from without will act precisely as increased internal attraction would, requiring a higher temperature to produce vaporization, and the higher the pressure the higher the temperature or repulsive force required, but the pressure increases much more rapidly than does the temperature because the force of attraction is steadily decreased as the temperature rises.

When heat is added to water when it is confined, producing only pressure or stress, that heat can produce no work in foot pounds so long as the pressure remains as the forces are neutralized in overcoming each other, just as heat added to a solid produces no work, the diamagnetic force being neutralized by the force of attraction.

Temperature indicates that state of negative atomic stress at which heat will pass from the hot to the cooler body, but it is

no indication of the pressure per square inch, except in vapors.

Vapor pressures do not depend upon the temperature, but on the difference in temperature between the temperature of the vapor and the temperature of the fusion. In the case of oxygen, with a liquifying temperature below —300°, a vapor pressure of 100 lbs. per square inch would develop at a temperature many degrees below zero, while water with a liquifying temperature of 32° develops a vapor pressure of 100 lbs. per square inch at 327.8° F. It therefore follows that when the force of attraction is reduced by the absorption of energy the vapor pressure is increased relative to the temperature, and when the force of attraction is increased by the radiation of energy, the pressure is decreased relative to the temperature.

When heat is added to water to produce vaporization, the water heated does not all tend to evaporate at once, but it vaporizes a molecule at a time, as we might say, and the

frequency with which the molecules are repelled is dependent on the amount of diamagnetic energy added to the liquid in a unit of time. If only repulsive force was produced by the added heat, then we would have reason to expect that all the water at the temperature of vaporization would tend to expand equally as in gaseous expansion and the temperature would rise as the expansion progressed at constant pressure, but it does not do so because of the high attractive force in the water, which force decreases as the heat is added, liberating a molecule at a time.

If we take one pound of oxygen and hydrogen uncombined as a liquid, at the vapor temperature of 918.5°, the pressure would be immensely higher than 450 lbs. per square inch, the pressure of water at this temperature, because of the very low attraction of the atoms for each other in these gases. Combustion would, therefore, seem to be simply a change in the atomic forces increasing the attraction and increasing the temperature relative to the pressure.

When steam say at 450 lbs. pressure is expanded it does not follow the rule of gaseous expansion, the pressure varying inversely as the square of the distance between the atoms, because in steam at the high pressure the atoms have a low force of attraction for each other, but the attractive force increases as the temperature falls with expansion, thus giving back the internal developed energy which went to decrease the force of attraction, as undeveloped energy and temperature to be redeveloped as external work, making the expansion almost equivalent to isothermal expansion as far as the pressure change is concerned, but the temperature change is not constant, being very much more rapid at the higher than it is at the lower pressures.

If we expand 1 lb. of steam from 450 lbs. pressure to double the volume, the work developed per degree drop in temperature in expansion only will be about 590 foot lbs., while a similar expansion from 5.6 lbs. pressure would give about 1,171 foot lbs. per

degree, so that the work done by the steam is not proportionate to its temperature change. This is no doubt because as the temperature decreases with expansion the force of attraction increases, and less of the energy neutralizes the force of attraction. In gaseous expansion the work developed for each degree drop in temperature is about the same, because there is practically no change in the force of attraction with change of temperature, due to the highly superheated condition of the gas.

When condensation takes place by expansion without radiation of heat, the heat of expansion which would be given off by the condensed atoms would naturally go to intensify the repulsive force in the live atoms which remain in the vapor state. We would thus have a continual concentration of the diamagnetic force, as the expansion progresses, into a less and less quantity of vapor. When the temperature falls below freezing in expansion the heat in the vapor would be further augmented by the heat

given off in solidification of all the vapor which has condensed. This concentration of heat would steadily increase the force of repulsion in the uncondensed vapor so that the vapor would expand to complete relaxation and zero, much like a gas, except that due to the concentration of the heat, as above outlined, it would probably follow the ratio of vapor expansion to the end, continuing to lose some by condensation progressively.

When the vapor is expanded separately, not being in contact with water, the temperature falls and the force of attraction in the atoms rises, thus increasing the temperature relative to the pressure, hence the sustained high temperature and great amount of work developed by expanding steam. The internal developed energy is changed to external developed energy as the attraction of the atoms increases.

The continual increase in the positive force with the corresponding increase in the negative force would probably continue till the zero of temperature, or temperature of com-

plete relaxation, has been reached, but only part of the original vapor would reach complete relaxation as much of it would condense, parting with its heat of expansion to the remaining vapor. The vapor would not become truly gaseous by expansion because of the high attractive force. The gaseous state in reasonable perfection can only exist in matter at a temperature very much above the temperature of fusion, or when greatly expanded, when the stress of attraction would be greatly diminished, due to the distance between the atoms.

The energy which goes to decrease the force of attraction in the water may be called latent heat, as it is this heat which comes back as sensible heat in expansion as the temperature falls, but it is not a satisfactory definition, as it is due to the decrease of the force of attraction that we have the high steam pressure at moderate temperature, so that from the standpoint of developing work it is not latent, the pressure is high because the attraction is low.

When energy is added to a solid the force of repulsion is increased and the force of attraction is decreased. When we expand water to a vapor at constant temperature the force of repulsion is increased, giving off work, while the force of attraction remains the same, but the stress of the attraction is decreased as the distance between the atoms increases. When a vapor is expanded the force of attraction is increased and the force of repulsion is increased, but the stress, due to these forces, is modified as the distance between the atoms increases, giving out work. When a gas is expanded only work is given out by the relaxation of the stress between the repelling atoms, so that the temperature of the gas represents closely the amount of undeveloped energy.

The reason why in the expansion of a vapor the increase in the positive force produces an increase in the negative force is because it loses no heat in expansion, but it develops work, losing temperature or stress,

the diamagnetic force can only be decreased by radiation or by chemical action.

That this is in part true, we know, because watery vapor does not cease to exist at 32°; snow may fall at 60° below zero, and there will still be watery vapor in the atmosphere when the snow has ceased falling. We may have watery vapor and ice in the same vessel. The condensation of water vapor is, therefore, not dependent on the temperature. It is dependent on the intensity of the diamagnetic force, on the force of repulsion between the atoms, otherwise on the relation of the force of repulsion to the force of attraction, and so a gas will remain a gas until the heat or diamagnetic force has been transferred, independent of what the temperature may be, while a vapor will continually lose by condensation as the expansion progresses because of the increasing high attractive force of the atoms.

What actually takes place when steam is expanded from a high to a low pressure has never been very clearly determined, but it

seems safe to say that one pound of vapor generated at 450 lbs. pressure and expanded at 26.79 cubic feet is not the same as one pound of vapor generated at 14.7 lbs. pressure.

In expansion the steam condenses to a certain extent, but it would seem that in true adiabatic expansion the condensation is less than is generally supposed, the condensation experienced in practice being, to a considerable extent, due to the radiation of heat.

Accurate knowledge of the amount of heat necessary to vaporize water to steam at the various pressures would throw much light on the subject, but it is difficult to see how the latent heat of evaporation could be accurately determined by the methods used at least in some cases. The latent heat as given at all pressures is probably excessive with the factor of error increasing very rapidly as the pressure increases. The external developed energy can be readily determined, while the internal developed energy and work done in pulling the atoms apart cannot

be determined except by experiment, but this work would be much greater at low temperatures because the attraction is higher and the extent of the diffusion is greater at the low pressure.

The evidence derived from experience would seem to indicate that there is more heat in 1 lb. of steam at 14.7 lbs. pressure than there is in 1 lb. of steam at 450 lbs. pressure, although there is more energy in the latter, because of the higher temperature, the difference in heat being the amount of heat necessary to re-evaporate the condensation which results from expanding the steam from 1.04 cubic feet to 26.79 cubic feet. This is borne out by the fact that if we take 1 lb. of steam generated at 14.7 lbs. pressure and compress it to 1.04 cubic feet, the resultant will not be 1 lb. of steam at 450 lbs. pressure, but the pressure will be much higher, and the steam will be considerably superheated.

The work given out in expansion represents external developed energy or decrease

in temperature, but does not change the amount of heat or diamagnetic force present. The amount of heat may be increased in expansion by friction or by a sudden increase in the volume, producing a dynamic action between the atoms, due to velocity. The character of the force must be changed from one of stress producing velocity to diamagnetic force producing temperature, and if all the energy of the steam expanded from a high pressure is absorbed by friction the steam will be superheated as the expansion progresses.

The reason why expanded steam is opaque is probably because as the force of attraction of the atoms increases an irregular grouping of the atoms takes place due to the increased attractive force tending to condensation, and the steam would thus be opaque from refraction.

In a gas the force of attraction has been largely eliminated, so that when heat is added to the gas it produces almost entirely increase in the force of repulsion, and in a

gas in expansion the pressure varies very nearly inversely as the square of the distance between the atoms and the temperature or vibro-frequency decreases directly proportionate to the relaxation of the atomic stress. If the gas was perfect, that is, without any atomic attraction whatever, it should follow the rule exactly.

Temperature is, therefore, no index of the energy contained in a solid, liquid or vapor, it simply indicates that relation of the forces at which heat will pass from one body to another; it represents the frequency of the vibration when heat is being transferred, and in no two kinds of matter in equal quantity does the same absorption of energy produce the same rise in temperature, nor does the same absorption of energy produce an equal rise in temperature throughout the scale in the same material; so that a temperature scale of equal degrees does not represent equal progressive changes of condition. Only in a gas are the changes comparatively regular over any considerable range of tem-

perature, because the force of attraction has been practically eliminated from the gas.

To speak of the heat which is transferred to the water to produce the vapor as being latent heat is quite misleading, just as to speak of the pressure of the vapor as being constant is misleading. The only way that the pressure change can be clearly understood is by taking spherical pressure or the pressure on the inside of a sphere inclosing the volume.

The spherical pressure of 1 lb. of water at 918.5° absolute is 19,890 lbs.
The spherical pressure of 1 lb. of vapor at 918.5° absolute is 318,240 lbs.
The spherical pressure of 1 lb. of water at 626° absolute is 247.52 lbs.
The spherical pressure of 1 lb. of vapor at 626° absolute is 53,365 lbs.

Despite the developed energy which results from increasing the volume, the spherical pressure has gone up greatly. Surely, the pressure from the water to the vapor has not been constant, although the pressure per square inch has been. How, therefore, can the heat be said to be latent?

It should be noted that the volume is increased not by expanding the vapor, but by increasing the quantity of vapor progressively, so that the condition of the vapor is always the same, and, therefore, the pressure per square inch and the temperature remain constant.

The changes which take place in a gas in expansion can be understandably defined as developed and undeveloped energy instead of as latent and sensible heat; thus, if one unit of energy 774 ft. lbs. is added to 73 cubic feet of hydrogen at 14.7 lbs. pressure and 499° absolute temperature and at constant volume, the temperature will be increased $\frac{1}{500}$ to 500° and the pressure will be increased $\frac{1}{500}$ of 14.7 lbs., or .0294 lbs. per square inch. We have added to the gas one unit of undeveloped energy, and the energy may be redeveloped as work by taking $\frac{1}{500}$ of 73 cubic feet of gas as defined, or .146 cubic feet, and expanding it to complete relaxation.

With hydrogen at constant pressure, take

52 cubic ft. of gas at 14.8 lbs. pressure and 499° temperature, by adding one unit of energy the temperature will rise $\frac{1}{500}$ to 500° and the volume will increase $\frac{1}{500}$, or .104 cubic ft. This increase in volume, .104 cubic ft., represents $144 \times 14.8 \times .104 = 222$ ft. lbs. developed energy. The .104 cubic ft. of gas as defined represents about 552 ft. lbs. undeveloped energy, thus giving a total of 774 ft. lbs., or one unit of energy as defined. The .104 cubic ft. of gas must be expanded adiabatically to complete relaxation or zero to develop all the energy, hence the unit of heat produced by friction is produced from zero. The remaining 52 cubic ft. of gas at 500° temperature would have exactly the same total undeveloped energy as the original 52 cubic ft. at 499°, because while the temperature is increased $\frac{1}{500}$, the quantity of gas is reduced $\frac{1}{500}$, the changes offsetting each other.

In dealing with liquids and solids the conditions are more complex, because the two forces have to be considered, and these are

continually changing their relationship. It may seem reasonable to hold that the energy which goes to increase the temperature of a solid is equivalent to undeveloped energy, while that which goes to decrease the force of attraction is developed energy, it being entirely neutralized in modifying the attractive force without affecting the temperature and is true latent energy in that it does internal work and reappears as undeveloped energy as the temperature decreases.

In vapors the subject becomes still more complex as there are not only the two forces to deal with under the condition of stress in the matter, but also the great changes in the volume which take place, so that it would not be possible to determine the amount of developed and undeveloped energy except by experiment, the work developed by a vapor in expansion not being proportionate to its temperature change, due to the reappearance of the internal developed energy as external energy as the temperature is reduced by expansion.

The undeveloped energy or the energy necessary to raise the temperature of one cubic foot of the solids 1° may probably be the same in all materials, but the developed energy, or energy absorbed to modify the force of attraction, would vary with the change in the intensity of the force of attraction in the material, and would increase as the stress, due to the rising temperature, increases. This conforms with the experience that the specific heat of metal increases with rising temperature, varying, however, with structural modifications which may take place. When heat is withdrawn from the metal the developed energy would reappear as undeveloped energy, as the force of attraction reasserts itself in a similar way the developed energy in a gas would reappear as undeveloped energy when the gas is compressed, but the heat in neither case has been latent; in the one case it decreases the force of attraction, in the other case it increases the volume, and that the heat is a definite

entity at all times without regard to the energy is apparent.

If we take two vessels, each containing 1 cubic ft. of hydrogen, at 14.7 pounds pressure and 499° absolute temperature, and transfer 1° of heat to the one at constant volume, making the temperature 500°, and we compress the other till the temperature stands at 500°, the energy in the two cases will be exactly the same, but the volumes are different. There is more heat in a larger volume because the atoms are further apart, requiring a higher repulsive force to give the 500° temperature. Heat added to a gas remains as diamagnetic force until it has been transferred by radiation, although it loses its energy and temperature by expansion.

If steam is expanded from 450 lbs. pressure to complete relaxation adiabatically and the process is then reversed, again, reducing the volume with the water of condensation remaining in the vessel, we would not simply scrape up the water with no expenditure of work, but the steam would redevelop as the

volume decreases and the water would re-evaporate as the temperature rises, because the heat remained in the expanded vapor, although the energy had gone into work. If the water of condensation is removed before reducing the volume, then the steam compressed to 450 lbs. would be highly superheated, because the water acts as a sponge to take up the heat as the temperature develops part of the absorbed heat going to decrease the force of attraction. There is heat and temperature, and when work is done in expansion by relaxing the stress it reduces the temperature, but the work done is not due to the disappearance of heat.

From the foregoing it should appear that heat is purely a diamagnetic force which tends to neutralize the positive force of attraction, and when the attraction has been overcome additional heat will produce the expansion or removing apart of the atoms, or groups of atoms, thereby relieving the stress and reducing the temperature; the force of repulsion being due to the diamag-

netic force of the atom and not to any vibration or giratory action of the atoms.

The development of heat by friction is an operation closely similar to that of producing electricity, and the magnetic phenomena associated with electric currents bear a strong resemblance to the diamagnetic phenomena associated with heat. The production or development in both cases results from moving a mass through a field of force. In friction the field of force being that due to the repulsion of the atoms in the material in contact, the intensity of the action being increased by pressure due to making the contact more intimate and the varying coefficients of friction between different materials being due probably to the varying intensity of the forces beween atoms of the dissimilar materials, the friction increasing as the temperature rises, and so it may appear that when two bodies are rubbed together they generate an electric current of such low voltage that it is not detectable as a current, and the resistance of matter to its

passage is so great that it is entirely converted into heat or diamagnetic force, and that this force is transmitted from atom to atom by the vibratory action of the force when the temperatures are different. In short, the positive force of the atomic attraction is changed by friction to the negative force of repulsion requiring energy to do so proportionate to the temperature.

All matter may be said to have in it the two forces in varying degrees of intensity. In a gas the force of attraction is very low, and so almost the entire energy added to a gas becomes available as work in expansion. In a vapor this is not the case, because in this matter the force of attraction is high and the atoms are held apart only by an intense force of repulsion or temperature.

While this relationship of opposite forces acting in the same matter may at first seem inconsistent, still it is entirely in harmony with our experience with magnetic forces. A piece of steel under the negative potential has in it the positive force of atomic attrac-

tion unimpaired, while the group of atoms constituting the steel will repel atoms of their own kind which may be outside the group.

The varying conductivities of the different metals and of the same metals when alloyed with a small quantity of others is, no doubt, due to the varying diamagnetic properties of the atoms or groups of atoms. The great variation which may occur with slight material changes is well illustrated in the varying magnetic properties of matter. The permeability and magnetic qualities varying widely with very slight changes in the composition.

In gases the vibro-frequency is dependent on the intensity of the stress, but the atoms are so far apart that the response is sluggish, hence gases transmit little heat except by convection.

No small body has of itself any appreciable property which we may call inertia, momentum, weight or potential energy. All these apparent properties are entirely dependent on the density of the field of force

in which the bodies move, and are entirely relative, just as the armature of a generator is dependent on the density of the field of force in which it rotates for the output of current.

What we call work is due to change of relationship, and when matter is so affected as to cause it to tend to change the relationship, but is held in check as in air held under pressure in a receiver, it represents latent energy as stress. We may define various forms of energy, as heat energy, radiant energy, chemical energy, etc., etc., and find that these names make convenient distinctions to denote the different phenomena, but there are in fact two forces, the force of attraction and the force of repulsion, and all energy, stress, work, weight, inertia and momentum are the direct results of variations in the relationship of these two forces, and that these forces change with great suddenness is to be seen in combustion wherein the attraction of the atoms is greatly increased.

We cannot have the one force without having the other, but either may be said to furnish work, depending on the relationship. We use energy to disturb the magnetic balance, and energy will be given out to re-establish the balance, although the adjustment may be made miles from where the disturbance took place, and the transmission may be made by vibratory action. In the transmission of heat there is transmitted only diamagnetic force through the vibration in the atoms of a field of force.

In dealing with heat and temperature it is most important that we should give consideration to both the heat and the temperature. If we have one unit of heat at 1000° absolute temperature, there is in it available as work the equivalent of only 500° or 774 ft. lbs., assuming the surrounding temperature to be 500° absolute, as the temperature below the surrounding temperature is not available. If we take the one unit of heat at 1000° and transfer half of the energy to additional matter, changing it into two units

of heat at 500°, we may have lost no energy, but all the available energy has gone, as it will then all be below the surrounding temperature and not available, just as water is available for power purposes only so long as it is above sea-level.

In dealing with heat, work and diamagnetic energy, the units which have been adopted having been taken by mere chance, involve the subject of thermo-dynamics in irregularities and confusion, which seems altogether unnecessary. Water is not a suitable medium from which to determine the unit of heat as related to the unit of matter, because only part of the energy added to the water is represented by temperature; also the water being in a transitional state, the temperature is affected by evaporation and the diamagnetic resistance is not constant over any considerable range of temperature.

The Fahrenheit scale of temperature is equally irregular, beginning nowhere and ending nowhere, while the size of the degree

is purely arbitrary. The unit of energy, 778 ft. lbs., is also an awkward figure with no suitable foundation for its adoption. As the gaseous state is the only one in which practically all the energy added to the matter is represented by temperature and pressure when the gas is dealt with at constant volume, it seems that the various units could be established from a unit of gas with much greater simplicity, and the following are suggested as substitutes for those now in use:

Retaining the foot pound as unity, if we take 200 cubic ft. of hydrogen at constant volume, and 14 lbs. pressure per sq. inch, and at the freezing temperature of water, calling this temperature 1000° absolute, the length of the degree will thus be but slightly less than one-half of the Fahrenheit degree.

Then to raise the temperature of 200 cubic feet of hydrogen from 999° to 1000° at constant volume, will be equivalent to 1000 ft. lbs. of work. To expand 200 cubic ft. of hydrogen as defined from 1000° to

999° will develop 1000 ft. lbs. of work, which we may call one unit of energy.

1 unit	of	heat	at	1000°	= 1000	foot	pounds
1	"	"	"	"	1° =	1	"	pound
1000 units	"	"	"		1° = 1000		"	pounds

1000 units of heat at 1000° temperature would be equivalent to 1,000,000 ft. lbs., or the theoretical work equivalent of 200 cubic ft. or hydrogen as defined, expanded to complete relaxation.

The increase in pressure developed by raising the temperature from 999° to 1000° would be 14 lbs. divided by 1000 = .014 lbs. The unit of matter as related to unit of heat would be 200 cubic ft. divided by 1000 = .2 cubic ft. hydrogen at 14 lbs. pressure and 1000° temperature. The .2 cubic ft. of hydrogen expanded to complete relaxation would give theoretically 1000 ft. lbs. of work. The displacement value of the .2 cubic ft. would be 403 ft. lbs.

None of the figures are entirely correct, but they are perhaps more so than those

generally used. The amount of hydrogen assumed is perhaps slightly excessive. The gas not being perfect, the relationship would vary some in practice.

There are, of course, much more than 1,000,000 ft. lbs. of energy represented in the 200 cubic ft. of hydrogen. There is all the energy which was necessary to neutralize the force of attraction, also the energy added to produce the volume or displacement equal to about 403,000 ft. lbs. But all of this energy is assumed to be developed energy, or neutralized by the distance between the atoms, so as to simplify the conception of the relationship between temperature and work.

When we deal with compressed air we must consider the compresion work and the displacement work, as well as the atmospheric back pressure, and when we deal with steam generated from water we must consider the displacement work and the expansion work, also the back pressure, whatever that may be. In expanding air adiabatically the work given out follows the temperature

change closely, so the relations established for hydrogen would be near enough for ordinary purposes, but in expanding steam the work given out is not proportionate to the temperature change, and the relations can only be established by equal degrees of work or energy given out, and not by degrees of temperature.

The units of energy suggested above would not apply to the temperature change by degrees in water, but this should be of no consequence as the specific heat of water changes with the temperature and can best be dealt with by units of energy. The relationship of other materials when given as specific heat or as diamagnetic resistance could be easily established from the new units.

The way in which the subject has been dealt with heretofore, using 1 lb. of water as the unit, contemplates the conversion of work into diamagnetic energy only, whereas the plan here outlined, using hydrogen, contemplates also the conversion of diamagnetic

energy into work, thus giving both the development of heat and the development of work in an understandable way.

One serious difficulty to making the subject understandable lies in the lack of a suitable and comprehensive nomenclature. The word "heat" should not be used in any other sense except as indicating the manifestation of heat, as the word "electricity" is used only to indicate the manifestation of an electric current. The various units should be given distinctive names indicating their value or relationship, much similar to those used in electrical science. It is not understandable to say that one unit of heat means heating an object from 40° to 41° or from 50° to 51° or from 100° to 101°; such a definition has no meaning. We can understand that one unit of energy may apply anywhere on the scale, but one unit of heat should mean all the heat present in one unit of matter, as we are dealing with matter and energy, and when the unit of matter remains constant the energy must vary with the

temperature. To say that 778 ft. lbs. of electrical energy is one unit of electricity has no meaning and is equivalent to saying that one unit of energy is equal to itself.